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DISTRICT COURT OF THE UNITED STATES.

SOUTHERN DISTRICT OF NEW YORK.

-----X
Nikola Tesla Company,

against

Marconi Wireless Telegraph Company
of America.
-----X

IN EQUITY.

TO THE HONORABLE THE JUDGES OF THE DISTRICT COURT
OF THE UNITED STATES IN AND FOR THE
SOUTHERN DISTRICT OF NEW YORK.

" 2

The Nikola Tesla Company, a corporation organized and existing under and by virtue of the laws of the State of New York and having its principal place of business in the City and County of New York, in said State, brings this, its bill of complaint, against the Marconi Wireless Telegraph Company of America, a corporation of the State of New Jersey, having its principal office in said State of New Jersey, and one or more regular and established places of business in the Borough of Manhattan, City, County and State of New York, and thereupon your orator complains and says:

" 3

1. That heretofore and before the 2nd day of September, 1897, one Nikola Tesla, then of the Borough of Manhattan, City, County and State of New York, was the original and first inventor of a certain new and useful system of transmission of electrical energy and of apparatus employed and constructed and arranged for said method and system of transmission of electrical energy, not known or used by others in this country and not patented or described in any printed publication in this or any foreign country before his invention or discovery thereof, and not in public

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use or on sale for more than two years prior to his application for a patent therefor.

2. That said Nikola Tesla, so being the inventor of said system, apparatus and improvements, made application to the Commissioner of Patents, in accordance with the then existing laws of the United States, and complied in all respects with the conditions and requirements of said laws.

3. That thereafter and on the 20th day of March, 1900, letters patent of the United States numbered No. 645,576, signed, sealed and executed in due form of law, and bearing date the day and year last aforesaid, were issued to said Nikola Tesla, whereby there was secured to him and to his heirs and assigns, for the term of seventeen years from the 20th day of March, 1900, the full and exclusive right of making, using and vending the said invention throughout the United States and the Territories thereof, as by said original letters patent or a certified copy thereof, in Court to be produced, will more fully appear. A printed copy of the specification and drawings of said letters patent No. 645,576 is hereto annexed and made a part of this bill.

4. That on the 15th day of May, 1900, letters patent of the United States numbered No. 649,621, signed, sealed and executed in due form of law, and bearing date the day and year last aforesaid, were issued to said Nikola Tesla, whereby there was secured to him and to his heirs and assigns, for the term of seventeen years from the 15th day of May, 1900, the full and exclusive right of making, using and vending the apparatus employed and constructed and arranged for methods and systems of transmission of elec-

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trical energy, throughout the United States and the Territories thereof, as by said original letters patent or a certified copy thereof, in Court to be produced, will more fully appear. A printed copy of the specification and drawings of said letters patent No. 649,621 is hereto annexed and made a part of this bill.

" 8

5. That on or about the 21st day of February, 1901, said Nikola Tesla, by an instrument in writing bearing date on said day, duly assigned, transferred and set over unto your orator, the Nikola Tesla Company, all his, the said Nikola Tesla's, right, title and interest in and to said letters patent Nos. 645,576 and 649,621, and the inventions thereby secured, as by said original assignment, in Court to be produced, will more fully and at large appear, and that by virtue of said assignment your orator became and now is the sole and exclusive owner of said letters patent, and of each of them, and of the inventions and improvements therein described and claimed, and of all rights secured by said letters patent since the date of said assignment.

" 9

6. That on or about the 10th day of November, 1900, subsequent to the dates of the issue of the two several letters patent above described to said Nikola Tesla, one Guglielmo Marconi, of London, England, made application to the Commissioner of Patents for a patent on an "apparatus for wireless telegraphy".

7. That thereafter and on the 28th day of June, 1904, alleged letters patent of the United States numbered No. 763,772 were issued to said Guglielmo Marconi, assignor of Marconi's Wireless Telegraph Company, Limited, of London,

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England, on said application, which letters patent describe the inventions and combinations of apparatus described and claimed in the said letters patent above set forth, theretofore issued to said Nikola Tesla. A printed copy of the specification and drawings of said letters patent No. 763,772 is hereto annexed and made a part of this bill.

" 11

8. On information and belief that the defendant above-named claims the right to use the alleged inventions described and claimed in said patent No. 763,772 in the Southern District of New York and elsewhere within the United States, and has infringed upon your orator's rights by using the inventions described and claimed in said letters patent of your orator Nos. 645,576 and 649,621, all of which works great and irreparable injury to your orator and to its rights in the premises.

" 12

9. To the end, therefore, that the said Marconi Wireless Telegraph Company of America may, if it can, show reason why your orator should not have relief, may it please your Honors to bring said defendant Marconi Wireless Telegraph Company of America before this Court by process of subpoena, there to make full, true, direct and perfect answer to the several matters and things herein set forth and charged (though not under oath, same being hereby expressly waived); and that a decree be made adjudging and declaring said letters patent No. 763,772 null and void, but that such adjudication shall affect only the right of said defendant and of any person deriving title through or under said defendant subsequent thereto; and for such other and further relief as the equities of the case may

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require and to your Honors may seem meet.

George M. D. Forter
.....
Solicitor for Complainant,
Office & P.O. Address,
32 Liberty Street,
Borough of Manhattan,
New York City.

NIKOLA TESLA COMPANY.

By *Nikola Tesla*
.....
President.

Lemuel E. Lugg
.....
Of Counsel.

" 14

State of New York, :
: ss:
County of New York, :

On this 16th day of April, 1915, before me
personally appeared Nikola Tesla, the President of the
Nikola Tesla Company, the complainant above-named, who,
being by me duly sworn, deposes and says that he is the
President of the Nikola Tesla Company and is familiar with
its business, and that he has read the foregoing bill of
complaint and knows the contents thereof, and that the
same is true of his own knowledge, except as to the matters
therein stated to be alleged on information and belief, and
that as to those matters he believes it to be true.

" 15

Subscribed and sworn to before me

this 16th day of April, 1915. *Nikola Tesla*
.....

Martha Fitzman
.....

NOTARY PUBLIC, KINGS CO.
CERTIFICATE FILED IN NEW YORK CO. #5



No. 645,576.

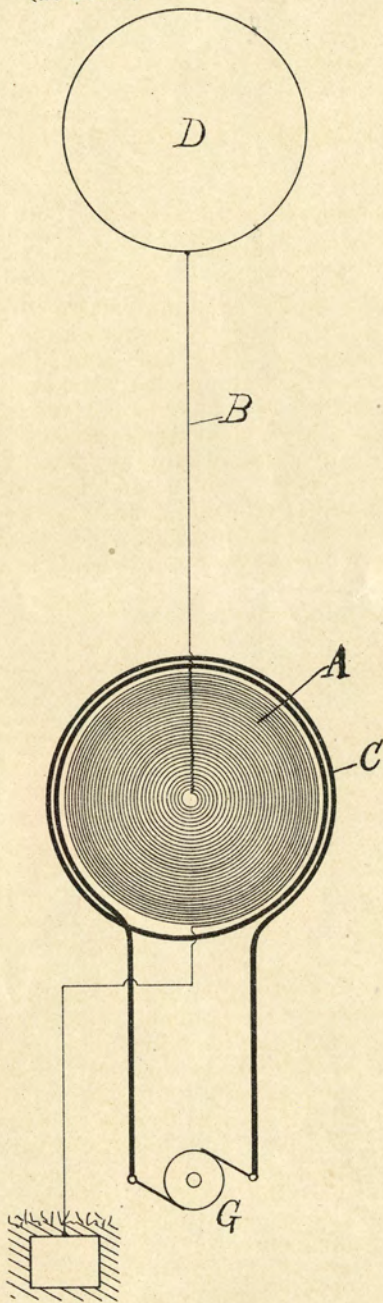
Patented Mar. 20, 1900.

N. TESLA.

SYSTEM OF TRANSMISSION OF ELECTRICAL ENERGY.

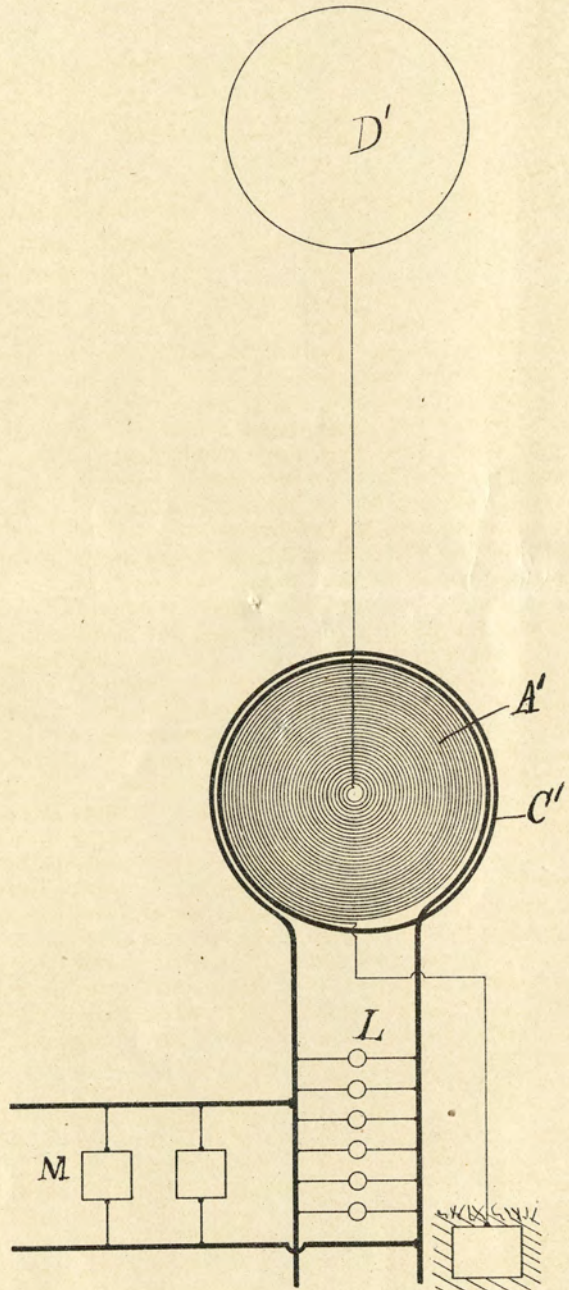
(Application filed Sept. 2, 1897.)

(No Model.)



WITNESSES

Dwight N. Cooper
M. Lawson Dyer



INVENTOR

Nikola Tesla
BY
Cur. Curtis & Page
ATTORNEYS.

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

SYSTEM OF TRANSMISSION OF ELECTRICAL ENERGY.

SPECIFICATION forming part of Letters Patent No. 645,576, dated March 20, 1900.

Application filed September 2, 1897. Serial No. 650,343. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems of Transmission of Electrical Energy, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

It has been well known heretofore that by rarefying the air inclosed in a vessel its insulating properties are impaired to such an extent that it becomes what may be considered as a true conductor, although one of admittedly very high resistance. The practical information in this regard has been derived from observations necessarily limited in their scope by the character of the apparatus or means heretofore known and the quality of the electrical effects producible thereby. Thus it has been shown by William Crookes in his classical researches, which have so far served as the chief source of knowledge of this subject, that all gases behave as excellent insulators until rarefied to a point corresponding to a barometric pressure of about seventy-five millimeters, and even at this very low pressure the discharge of a high-tension induction-coil passes through only a part of the attenuated gas in the form of a luminous thread or arc, a still further and considerable diminution of the pressure being required to render the entire mass of the gas inclosed in a vessel conducting. While this is true in every particular so long as electromotive or current impulses such as are obtainable with ordinary forms of apparatus are employed, I have found that neither the general behavior of the gases nor the known relations between electrical conductivity and barometric pressure are in conformity with these observations when impulses are used such as are producible by methods and apparatus devised by me and which have peculiar and hitherto unobserved properties and are of effective electromotive forces, measuring many hundred thousands or millions of volts. Through the continuous perfection of these methods and apparatus and the investigation of the actions of these current impulses I have been led to the discovery of certain highly-important and useful facts which have hitherto been

unknown. Among these and bearing directly upon the subject of my present application are the following: First, that atmospheric or other gases, even under normal pressure, when they are known to behave as perfect insulators, are in a large measure deprived of their dielectric properties by being subjected to the influence of electromotive impulses of the character and magnitude I have referred to and assume conducting and other qualities which have been so far observed only in gases greatly attenuated or heated to a high temperature, and, second, that the conductivity imparted to the air or gases increases very rapidly both with the augmentation of the applied electrical pressure and with the degree of rarefaction, the law in this latter respect being, however, quite different from that heretofore established. In illustration of these facts a few observations, which I have made with apparatus devised for the purposes here contemplated, may be cited. For example, a conductor or terminal, to which impulses such as those here considered are supplied, but which is otherwise insulated in space and is remote from any conducting-bodies, is surrounded by a luminous flame-like brush or discharge often covering many hundreds or even as much as several thousands of square feet of surface, this striking phenomenon clearly attesting the high degree of conductivity which the atmosphere attains under the influence of the immense electrical stresses to which it is subjected. This influence is, however, not confined to that portion of the atmosphere which is discernible by the eye as luminous and which, as has been the case in some instances actually observed, may fill the space within a spherical or cylindrical envelop of a diameter of sixty feet or more, but reaches out to far remote regions, the insulating qualities of the air being, as I have ascertained, still sensibly impaired at a distance many hundred times that through which the luminous discharge projects from the terminal and in all probability much farther. The distance extends with the increase of the electromotive force of the impulses, with the diminution of the density of the atmosphere, with the elevation of the active terminal above the ground, and also, apparently, in a slight measure, with the degree of moisture contained in

the air. I have likewise observed that this region of decidedly-noticeable influence continuously enlarges as time goes on, and the discharge is allowed to pass not unlike a con-
 5 flagration which slowly spreads, this being possibly due to the gradual electrification or ionization of the air or to the formation of less insulating gaseous compounds. It is, furthermore, a fact that such discharges of
 10 extreme tensions, approximating those of lightning, manifest a marked tendency to pass upward away from the ground, which may be due to electrostatic repulsion, or possibly to slight heating and consequent rising of the
 15 electrified or ionized air. These latter observations make it appear probable that a discharge of this character allowed to escape into the atmosphere from a terminal maintained at a great height will gradually leak
 20 through and establish a good conducting-path to more elevated and better conducting air strata, a process which possibly takes place in silent lightning discharges frequently witnessed on hot and sultry days. It will be
 25 apparent to what an extent the conductivity imparted to the air is enhanced by the increase of the electromotive force of the impulses when it is stated that in some instances the area covered by the flame discharge mentioned
 30 was enlarged more than sixfold by an augmentation of the electrical pressure, amounting scarcely to more than fifty per cent. As to the influence of rarefaction upon the electric conductivity imparted to the gases it
 35 is noteworthy that, whereas the atmospheric or other gases begin ordinarily to manifest this quality at something like seventy-five millimeters barometric pressure with the impulses of excessive electromotive force to which I have referred, the conductivity, as
 40 already pointed out, begins even at normal pressure and continuously increases with the degree of tenuity of the gas, so that at, say, one hundred and thirty millimeters pressure,
 45 when the gases are known to be still nearly perfect insulators for ordinary electromotive forces, they behave toward electromotive impulses of several millions of volts like excellent conductors, as though they were rarefied
 50 to a much higher degree. By the discovery of these facts and the perfection of means for producing in a safe, economical, and thoroughly-practicable manner current impulses of the character described it becomes possible
 55 to transmit through easily-accessible and only moderately-rarefied strata of the atmosphere electrical energy not merely in insignificant quantities, such as are suitable for the operation of delicate instruments and like purposes, but also in quantities suitable for industrial
 60 uses on a large scale up to practically any amount and, according to all the experimental evidence I have obtained, to any terrestrial distance. To conduce to a better understanding of this method of transmission
 65 of energy and to distinguish it clearly, both in its theoretical aspect and in its practical

bearing, from other known modes of transmission, it is useful to state that all previous efforts made by myself and others for transmitting electrical energy to a distance without the use of metallic conductors, chiefly
 70 with the object of actuating sensitive receivers, have been based, in so far as the atmosphere is concerned, upon those qualities which it possesses by virtue of its being an excellent insulator, and all these attempts would
 75 have been obviously recognized as ineffective if not entirely futile in the presence of a conducting atmosphere or medium. The utilization of any conducting properties of the air for purposes of transmission of energy
 80 has been hitherto out of the question in the absence of apparatus suitable for meeting the many and difficult requirements, although it has long been known or surmised that atmospheric strata at great altitudes—say fifteen or more miles above sea-level—are, or
 85 should be, in a measure, conducting; but assuming even that the indispensable means should have been produced then still a difficulty, which in the present state of the mechanical arts must be considered as insuperable, would remain—namely, that of maintaining terminals at elevations of fifteen miles
 90 or more above the level of the sea. Through my discoveries before mentioned and the production of adequate means the necessity of maintaining terminals at such inaccessible altitudes is obviated and a practical method
 95 and system of transmission of energy through the natural media is afforded essentially different from all those available up to the present time and possessing, moreover, this important practical advantage, that whereas in
 100 all such methods or systems heretofore used or proposed but a minute fraction of the total energy expended by the generator or transmitter was recoverable in a distant receiving apparatus by my method and appliances it
 105 is possible to utilize by far the greater portion of the energy of the source and in any locality however remote from the same.

Expressed briefly, my present invention, based upon these discoveries, consists then
 115 in producing at one point an electrical pressure of such character and magnitude as to cause thereby a current to traverse elevated strata of the air between the point of generation and a distant point at which the energy
 120 is to be received and utilized.

In the accompanying drawing a general arrangement of apparatus is diagrammatically illustrated such as I contemplate employing in the carrying out of my invention
 125 on an industrial scale—as, for instance, for lighting distant cities or districts from places where cheap power is obtainable.

Referring to the drawing, A is a coil, generally of many turns and of a very large diameter, wound in spiral form either about a
 130 magnetic core or not, as may be found necessary. C is a second coil, formed of a conductor of much larger section and smaller

length, wound around and in proximity to the coil A. In the transmitting apparatus the coil A constitutes the high-tension secondary and the coil C the primary of much lower tension of a transformer. In the circuit of the primary C is included a suitable source of current G. One terminal of the secondary A is at the center of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed or maintained by such means as a balloon at an elevation suitable for the purposes of transmission, as before described. The other terminal of the secondary A is connected to earth and, if desired, also to the primary in order that the latter may be at substantially the same potential as the adjacent portions of the secondary, thus insuring safety. At the receiving-station a transformer of similar construction is employed; but in this case the coil A', of relatively-thin wire, constitutes the primary and the coil C', of thick wire or cable, the secondary of the transformer. In the circuit of the latter are included lamps L, motors M, or other devices for utilizing the current. The elevated terminal D' is connected with the center of the coil A', and the other terminal of said coil is connected to earth and preferably, also, to the coil C' for the reasons above stated.

It will be observed that in coils of the character described the potential gradually increases with the number of turns toward the center, and the difference of potential between the adjacent turns being comparatively small a very high potential, impracticable with ordinary coils, may be successfully obtained. It will be, furthermore, noted that no matter to what an extent the coils may be modified in design and construction, owing to their general arrangement and manner of connection, as illustrated, those portions of the wire or apparatus which are highly charged will be out of reach, while those parts of the same which are liable to be approached, touched, or handled will be at or nearly the same potential as the adjacent portions of the ground, thus insuring, both in the transmitting and receiving apparatus and regardless of the magnitude of the electrical pressure used, perfect personal safety, which is best evidenced by the fact that although such extreme pressures of many millions of volts have been for a number of years continuously experimented with no injury has been sustained neither by myself or any of my assistants.

The length of the thin-wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used. By way of illustration if the rate at which the current traverses the circuit, including the coil, be one hundred and eighty-five thou-

sand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length. For such a low frequency, to which I shall resort only when it is indispensable to operate motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or porportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D', and it should be understood that whatever length be given to the wires this condition should be complied with in order to attain the best results.

As the main requirement in carrying out my invention is to produce currents of an excessively-high potential, this object will be facilitated by using a primary current of very considerable frequency, since the electromotive force obtainable with a given length of conductor is proportionate to the frequency; but the frequency of the current is in a large measure arbitrary, for if the potential be sufficiently high and if the terminals of the coils be maintained at the proper altitudes the action described will take place, and a current will be transmitted through the elevated air strata, which will encounter little and possibly even less resistance than if conveyed through a copper wire of a practicable size. Accordingly the construction of the apparatus may be in many details greatly varied; but in order to enable any person skilled in the mechanical and electrical arts to utilize to advantage in the practical applications of my system the experience I have so far gained the following particulars of a model plant which has been long in use and which was constructed for the purpose of obtaining further data to be used in the carrying out of my invention on a large scale are given. The transmitting apparatus was in this case one of my electrical oscillators, which are transformers of a special type, now well known and characterized by the passage of oscillatory discharges of a condenser through the primary. The source G, forming one of the elements of the transmitter, was a condenser of a capacity of about four one-hundredths of a microfarad and was charged from a generator of alternating currents of fifty thousand volts pressure and discharged by means of a mechanically-operated break five thousand times per second through the primary C. The latter consisted of a single turn of stout stranded cable of inappreciable resistance and of an inductance of about eight thousand centimeters, the diameter of the loop being very nearly two hundred and forty-four centimeters. The total inductance of the primary circuit was approximately ten thousand centimeters, so that the primary circuit vibrated generally according to adjustment,

from two hundred and thirty thousand to two hundred and fifty thousand times per second. The high-tension coil A in the form of a flat spiral was composed of fifty turns of heavily-insulated cable No. 8 wound in one single layer, the turns beginning close to the primary loop and ending near its center. The outer end of the secondary or high-tension coil A was connected to the ground, as illustrated, while the free end was led to a terminal placed in the rarefied air stratum through which the energy was to be transmitted, which was contained in an insulating-tube of a length of fifty feet or more, within which a barometric pressure varying from about one hundred and twenty to one hundred and fifty millimeters was maintained by means of a mechanical suction-pump. The receiving-transformer was similarly proportioned, the ratio of conversion being the reciprocal of that of the transmitter, and the primary high-tension coil A' was connected, as illustrated, with the end near the low-tension coil C' to the ground and with the free end to a wire or plate likewise placed in the rarefied air stratum and at the distance named from the transmitting-terminal. The primary and secondary circuits in the transmitting apparatus being carefully synchronized, an electromotive force from two to four million volts and more was obtainable at the terminals of the secondary coil A, the discharge passing freely through the attenuated air stratum maintained at the above barometric pressures, and it was easy under these conditions to transmit with fair economy considerable amounts of energy, such as are of industrial moment, to the receiving apparatus for supplying from the secondary coil C' lamps L or kindred devices. The results were particularly satisfactory when the primary coil or system A', with its secondary C', was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system A C. I have, however, found no difficulty in producing with apparatus of substantially the same design and construction electromotive forces exceeding three or four times those before mentioned and have ascertained that by their means current impulses can be transmitted through much-denser air strata. By the use of these I have also found it practicable to transmit notable amounts of energy through air strata not in direct contact with the transmitting and receiving terminals, but remote from them, the action of the impulses, in rendering conducting air of a density at which it normally behaves as an insulator, extending, as before remarked, to a considerable distance. The high electromotive force obtained at the terminals of coil or conductor A was, as will be seen, in the preceding instance, not so much due to a large ratio of transformation as to the joint effect of the capacities and inductances in the synchronized circuits, which effect is enhanced by a high frequency, and it will be obviously un-

derstood that if the latter be reduced a greater ratio of transformation should be resorted to, especially in cases in which it may be deemed of advantage to suppress as much as possible, and particularly in the transmitting-coil A, the rise of pressure due to the above effect and to obtain the necessary electromotive force solely by a large transformation ratio.

While electromotive forces such as are produced by the apparatus just described may be sufficient for many purposes to which my system will or may be applied, I wish to state that I contemplate using in an industrial undertaking of this kind forces greatly in excess of these, and with my present knowledge and experience in this novel field I would estimate them to range from twenty to fifty million volts and possibly more. By the use of these much greater forces larger amounts of energy may be conveyed through the atmosphere to remote places or regions, and the distance of transmission may be thus extended practically without limit.

As to the elevation of the terminals D D' it is obvious that it will be determined by a number of things, as by the amount and quality of the work to be performed, by the local density and other conditions of the atmosphere, by the character of the surrounding country, and such considerations as may present themselves in individual instances. Thus if there be high mountains in the vicinity the terminals should be at a greater height, and generally they should always be, if practicable, at altitudes much greater than those of the highest objects near them in order to avoid as much as possible the loss by leakage. In some cases when small amounts of energy are required the high elevation of the terminals, and more particularly of the receiving-terminal D', may not be necessary, since, especially when the frequency of the currents is very high, a sufficient amount of energy may be collected at that terminal by electrostatic induction from the upper air strata, which are rendered conducting by the active terminal of the transmitter or through which the currents from the same are conveyed.

With reference to the facts which have been pointed out above it will be seen that the altitudes required for the transmission of considerable amounts of electrical energy in accordance with this method are such as are easily accessible and at which terminals can be safely maintained, as by the aid of captive balloons supplied continuously with gas from reservoirs and held in position securely by steel wires or by any other means, devices, or expedients, such as may be contrived and perfected by ingenious and skilled engineers. From my experiments and observations I conclude that with electromotive impulses not greatly exceeding fifteen or twenty million volts the energy of many thousands of horse-power may be transmitted over vast distances, measured by many hundreds and

even thousands of miles, with terminals not more than thirty to thirty-five thousand feet above the level of the sea, and even this comparatively-small elevation will be required chiefly for reasons of economy, and, if desired, it may be considerably reduced, since by such means as have been described practically any potential that is desired may be obtained, the currents through the air strata may be rendered very small, whereby the loss in the transmission may be reduced.

It will be understood that the transmitting as well as the receiving coils, transformers, or other apparatus may be in some cases movable—as, for example, when they are carried by vessels floating in the air or by ships at sea. In such a case, or generally, the connection of one of the terminals of the high-tension coil or coils to the ground may not be permanent, but may be intermittently or inductively established, and any such or similar modifications I shall consider as within the scope of my invention.

While the description here given contemplates chiefly a method and system of energy transmission to a distance through the natural media for industrial purposes, the principles which I have herein disclosed and the apparatus which I have shown will obviously have many other valuable uses—as, for instance, when it is desired to transmit intelligible messages to great distances, or to illuminate upper strata of the air, or to produce, designedly, any useful changes in the condition of the atmosphere, or to manufacture from the gases of the same products, as nitric acid, fertilizing compounds, or the like, by the action of such current impulses, for all of which and for many other valuable purposes they are eminently suitable, and I do not wish to limit myself in this respect. Obviously, also, certain features of my invention here disclosed will be useful as disconnected from the method itself—as, for example, in other systems of energy transmission, for whatever purpose they may be intended, the transmitting and receiving transformers arranged and connected as illustrated, the feature of a transmitting and receiving coil or conductor, both connected to the ground and to an elevated terminal and adjusted so as to vibrate in synchronism, the proportioning of such conductors or coils, as above specified, the feature of a receiving-transformer with its primary connected to earth and to an elevated terminal and having the operative devices in its secondary, and other features or particulars, such as have been described in this specification or will readily suggest themselves by a perusal of the same.

I do not claim in this application a transformer for developing or converting currents of high potential in the form herewith shown and described and with the two coils connected together, as and for the purpose set forth, having made these improvements the subject of a patent granted to me November

2, 1897, No. 593,138, nor do I claim herein the apparatus employed in carrying out the method of this application when such apparatus is specially constructed and arranged for securing the particular object sought in the present invention, as these last-named features are made the subject of an application filed as a division of this application on February 19, 1900, Serial No. 5,780.

What I now claim is—

1. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing at a generating-station a very high electrical pressure, causing thereby a propagation or flow of electrical energy, by conduction, through the earth and the air strata, and collecting or receiving at a distant point the electrical energy so propagated or caused to flow.

2. The method hereinbefore described of transmitting electrical energy, which consists in producing at a generating-station a very high electrical pressure, conducting the current caused thereby to earth and to a terminal at an elevation at which the atmosphere serves as a conductor therefor, and collecting the current by a second elevated terminal at a distance from the first.

3. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby a propagation or flow of electrical energy, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station the electrical energy so propagated or caused to flow.

4. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render the air strata at or near the elevated terminal conducting, causing thereby a propagation or flow of electrical energy, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station the electrical energy so propagated or caused to flow.

5. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, electrical impulses of a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby current impulses to pass, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station, the energy of the current impulses by means of a circuit synchronized with the impulses.

6. The method hereinbefore described of

No. 649,621.

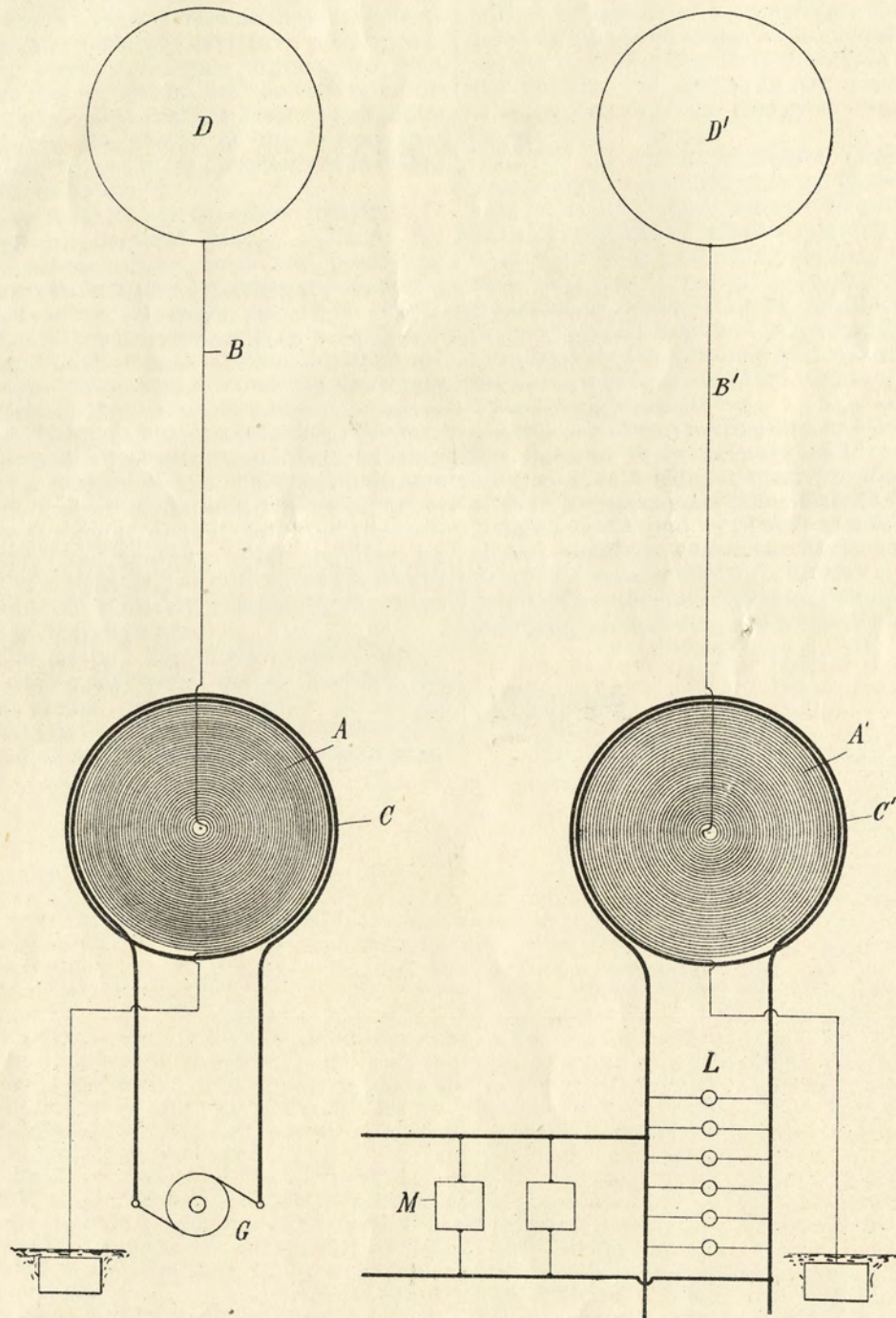
Patented May 15, 1900.

N. TESLA.

APPARATUS FOR TRANSMISSION OF ELECTRICAL ENERGY.

(Application filed Feb. 19, 1900.)

(No Model.)



Witnesses:
Bryan Miller.
G. W. Martling.

Nikola Tesla, Inventor
by *Ken. Page & Co.* Attys

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR TRANSMISSION OF ELECTRICAL ENERGY.

SPECIFICATION forming part of Letters Patent No. 648,621, dated May 15, 1900.

Original application filed September 2, 1897, Serial No. 650,343. Divided and this application filed February 19, 1900. Serial No. 5,780. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city of New York, county and State of New York, have invented certain new and useful Improvements in Apparatus for the Transmission of Electrical Energy, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

This application is a division of an application filed by me on September 2, 1897, Serial No. 650,343, entitled "Systems of transmissions of electrical energy," and is based upon new and useful features and combinations of apparatus shown and described in said application for carrying out the method therein disclosed and claimed.

The invention which forms the subject of my present application comprises a transmitting coil or conductor in which electrical currents or oscillations are produced and which is arranged to cause such currents or oscillations to be propagated by conduction through the natural medium from one point to another remote therefrom and a receiving coil or conductor at such distant point adapted to be excited by the oscillations or currents propagated from the transmitter.

This apparatus is shown in the accompanying drawing, which is a diagrammatic illustration of the same.

A is a coil, generally of many turns and of a very large diameter, wound in spiral form either about a magnetic core or not, as may be desired. C is a second coil formed by a conductor of much larger size and smaller length wound around and in proximity to the coil A.

The apparatus at one point is used as a transmitter, the coil A in this case constituting a high-tension, secondary, and the coil C the primary, of much lower tension, of a transformer. In the circuit of the primary C is included a suitable source of current G. One terminal of the secondary A is at the center of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed or maintained by such means as a balloon at an

elevation suitable for the purposes of transmission. The other terminal of the secondary A is connected to earth, and, if desired, to the primary also, in order that the latter may be at substantially the same potential as the adjacent portions of the secondary, thus insuring safety. At the receiving-station a transformer of similar construction is employed; but in this case the longer coil A' constitutes the primary, and the shorter coil C' the secondary, of the transformer. In the circuit of the latter are connected lamps L, motors M, or other devices for utilizing the current. The elevated terminal D' connects with the center of the coil A', and the other terminal of said coil is connected to earth and preferably, also, to the coil C' for the reasons above stated.

The length of the thin wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used. By way of illustration, if the rate at which the current traverses the circuit including the coil be one hundred and eighty-five thousand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length.

For such a low frequency, which would be resorted to only when it is indispensable for the operation of motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D', and it should be understood that whatever length be given to the wires this requirement should be complied with in order to obtain the best results.

It will be readily understood that when the above-prescribed relations exist the best conditions for resonance between the transmit-

ting and receiving circuits are attained, and owing to the fact that the points of highest potential in the coils or conductors A A' are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations.

When the source of current G is in operation and produces rapidly pulsating or oscillating currents in the circuit of coil C, corresponding induced currents of very much higher potential are generated in the secondary coil A, and since the potential in the same gradually increases with the number of turns toward the center and the difference of potential between the adjacent turns is comparatively small a very high potential impracticable with ordinary coils may be successively obtained.

As the main object for which the apparatus is designed is to produce a current of excessively-high potential, this object is facilitated by using a primary current of very considerable frequency; but the frequency of the currents is in a large measure arbitrary, for if the potential be sufficiently high and the terminals of the coils be maintained at the proper elevation where the atmosphere is rarefied the stratum of air will serve as a conducting medium for the current produced and the latter will be transmitted through the air, with, it may be, even less resistance than through an ordinary conductor.

As to the elevation of the terminals D D', it is obvious that this is a matter which will be determined by a number of things, as by the amount and quality of the work to be performed, by the condition of the atmosphere, and also by the character of the surrounding country. Thus if there be high mountains in the vicinity the terminals should be at a greater height, and generally they should always be at an altitude much greater than that of the highest objects near them. Since by the means described practically any potential that is desired may be produced, the currents through the air strata may be very small, thus reducing the loss in the air.

The apparatus at the receiving-station responds to the currents propagated from the transmitter in a manner which will be well understood from the foregoing description. The primary circuit of the receiver—that is, the thin wire coil A'—is excited by the currents propagated by conduction through the intervening natural medium from the transmitter, and these currents induce in the secondary coil C' other currents which are utilized for operating the devices included in the circuit thereof.

Obviously the receiving-coils, transformers, or other apparatus may be movable—as, for instance, when they are carried by a vessel floating in the air or by a ship at sea. In

the former case the connection of one terminal of the receiving apparatus to the ground might not be permanent, but might be intermittently or inductively established without departing from the spirit of my invention.

It is to be noted that the phenomenon here involved in the transmission of electrical energy is one of true conduction and is not to be confounded with the phenomena of electrical radiation which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distances as are of practical importance.

What I now claim as my invention is—

1. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and means for producing therein electrical currents or oscillations, of a receiving coil or conductor similarly connected to ground and to an elevated terminal, at a distance from the transmitting-coil and adapted to be excited by currents caused to be propagated from the same by conduction through the intervening natural medium, a secondary conductor in inductive relation to the receiving-conductor and devices for utilizing the current in the circuit of said secondary conductor, as set forth.

2. The combination with a transmitting coil or conductor having its ends connected to ground and to an elevated terminal respectively, a primary coil in inductive relation thereto and a source of electrical oscillations in said primary circuit, of a receiving conductor or coil having its ends connected to ground and to an elevated terminal respectively and adapted to be excited by currents caused to be propagated from the transmitter through the natural medium and a secondary circuit in inductive relation to the receiving-circuit and receiving devices connected therewith, as set forth.

3. The combination with a transmitting instrument comprising a transformer having its secondary connected to ground and to an elevated terminal respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to ground and to an elevated terminal, and a translating device connected with its secondary, the capacity and inductance of the two transformers having such values as to secure synchronism with the impressed oscillations, as set forth.

4. The combination with a transmitting instrument comprising an electrical transformer having its secondary connected to ground and to an elevated terminal respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to ground and to an elevated terminal, and a translating

ing device connected with its secondary, the capacity and inductance of the secondary of the transmitting and primary of the receiving instruments having such values as to secure synchronism with the impressed oscillations, as set forth.

5 5. The combination with a transmitting coil or conductor connected to ground and an elevated terminal respectively, and means for producing electrical currents or oscillations in the same, of a receiving coil or conductor similarly connected to ground and to an elevated terminal and synchronized with the transmitting coil or conductor, as set forth.

10 6. The combination with a transmitting instrument comprising an electrical transformer, having its secondary connected to ground and to an elevated terminal respectively, of a receiving instrument comprising a transformer, having its primary similarly connected to ground and to an elevated terminal, the receiving-coil being synchronized with that of the transmitter, as set forth.

15 7. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and means for producing electrical currents or oscillations in the same, of a receiving coil or conductor similarly connected to ground and to an elevated terminal, the said coil or coils having a length equal to one-quarter of the wave

length of the disturbance propagated, as set forth.

8. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and adapted to cause the propagation of currents or oscillations by conduction through the natural medium, of a receiving-circuit similarly connected to ground and to an elevated terminal, and of a capacity and inductance such that its period of vibration is the same as that of the transmitter, as set forth.

9. The transmitting or receiving circuit herein described, connected to ground and an elevated terminal respectively, and arranged in such manner that the elevated terminal is charged to the maximum potential developed in the circuit, as set forth.

10. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively of a receiving-circuit having a period of vibration corresponding to that of the transmitting-circuit and similarly connected to ground and to an elevated terminal and so arranged that the elevated terminal is charged to the highest potential developed in the circuit, as set forth.

NIKOLA TESLA.

Witnesses:

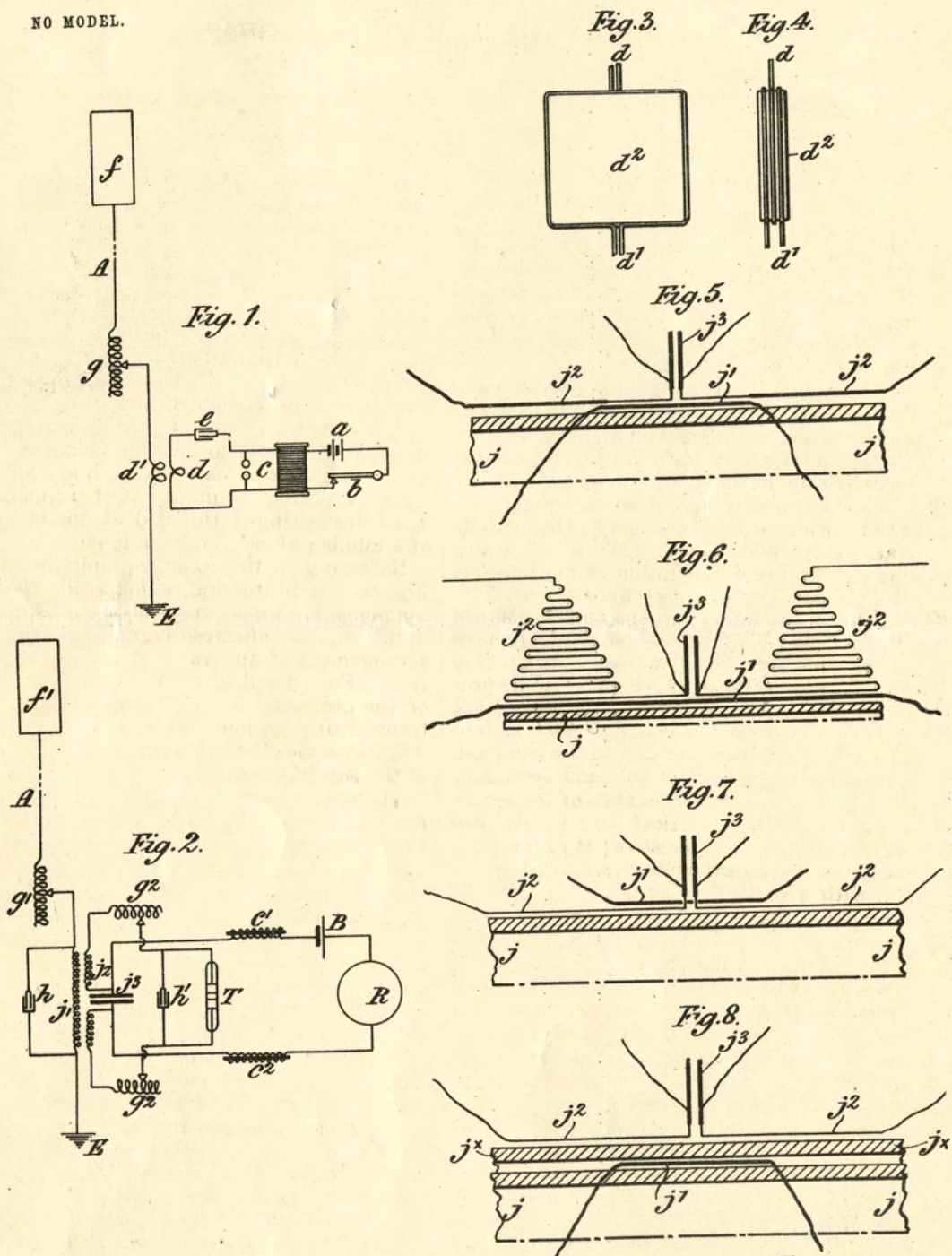
PARKER W. PAGE,
MARCELLUS BAILEY.

No. 763,772.

PATENTED JUNE 28, 1904.

G. MARCONI.
APPARATUS FOR WIRELESS TELEGRAPHY.
APPLICATION FILED NOV. 10, 1900.

NO MODEL.



Witnesses.
John H. Burroughs
James C. Logan

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 763,772, dated June 28, 1904.

Application filed November 10, 1900. Serial No. 36,010. (No model.)

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, electrician, a subject of the King of Italy, residing and having a post-office address at 18 Finch Lane, Threadneedle street, in the city of London, England, have invented certain new and useful Improvements in Apparatus for Wireless Telegraphy, of which the following is a specification.

10 My invention relates to apparatus for communicating electrical signals without wires and by means of Hertz oscillations or electric waves; and the object of the invention is to increase the efficiency of the system and to provide new and simple means whereby oscil-

15 lations or electric waves from a transmitting-station may be localized when desired at any one selected receiving station or stations out of a group of several receiving-stations. In my prior United States patent No. 586,193 (Reissue No. 11,913, dated June 4, 1901) I have shown and described the combination at a transmitting-station of an oscillation-producer, such as an induction-coil, having one end of its secondary coil connected to one contact of a spark-producer and to the earth and having the other end of the said secondary connected to the opposite contact of the spark-producer and to a vertical wire or elevated plate, and I have further shown at a receiving-station an imperfect contact connected in circuit with a vertical receiving-wire and with the earth. According to the present invention the system includes at the transmitting-station the combination, with an oscillation-transformer of a kind suitable for the transformation of very rapidly alternating currents, of a persistent oscillator, and a good radiator, one coil of said transformer being connected between the aerial wire or plate and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, a producer of Hertzian oscillations or electric waves shown in the form of a spark-producer, and an induction-coil (constituting the persistent oscillator) controlled by a signaling instrument. The complete system also includes at a receiving-station an oscillation-transformer one coil whereof is

included between the aerial receiving-wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit with the other coil of said transformer. The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductance of the two circuits at each station to accord with each other. By this arrangement of apparatus I am able to secure a perfect "tuning" of the apparatus at a transmitting-station and at one or more of a number of receiving-stations.

Referring to the accompanying drawings. Figure 1 indicates diagrammatically the arrangement of apparatus at a transmitting-station. Fig. 2 indicates diagrammatically the arrangement of apparatus at a receiving-station. Figs. 3 and 4 are views, plan and side, of the preferred form of transformer at the transmitting-station. Figs. 5, 6, 7, and 8 are diagrammatic views of forms of transformers at the receiving-station.

The transmitting-station is provided under my present invention with a source *a* of current electrically connected in circuit with the primary of an induction-coil *c* and with a circuit-closing key *b* or otherwise controlled by a signaling instrument. In the secondary circuit of said induction-coil the spherical terminals or other contacts of a spark-producer or other electric-wave or oscillation producer are included with a shunt therefrom, in which shunt is included the primary coil *d* of an oscillation-transformer, such as *d'*. A condenser *e*, preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other, is included in one connection from the induction-coil to the transformer-winding *d*. The secondary coil *d'* of the transformer is connected (at one end) to the earth *E* and at its other end to a vertical wire *A* or an elevated plate *f*.

It is obvious that instead of the induction-

coil and associated parts for producing the electric waves or oscillations I may use any other proper means for producing such waves or oscillations—such, for instance, as a generator of alternating electric currents.

The illustrated arrangement of parts at a transmitting-station enables much more energy to be imparted to the radiator f , the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting-station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit and use a good radiator—*i. e.*, an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit.

In operation the signaling-key b is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser e is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor.

For the best results and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be localized I include in the open secondary circuit of the transformer, and preferably between the radiator f and the secondary coil d' , an inductance-coil g , Fig. 1, having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment.

At the receiving-stations employing my present invention I prefer to use a receiver such as those described in my several United States Patents, Nos. 586,193, 627,650, 647,007, 647,008, 647,009, and 668,315, capable of being affected by electrical waves or oscillations of high frequency.

As a responder to electric waves I may use at the receiving-station any of the now well-known forms of such devices, such as those which depend for their action on the reduction of the resistance of a metallic microphone by the action of electric waves or “coherers,” one form of which is disclosed in my Patent No. 586,193, or I may employ one which depends for its action on the increase of the re-

sistance of the device under the influence of the electric waves or “anticoherers,” such as described by Branly in *La Lumiere Electrique* of June 13, 1891, or I may use those which depend upon the action of an electric wave as a magnetizing or demagnetizing agency, such as I have disclosed in my application Serial No. 132,974, filed November 28, 1902, or I may use various other well-known devices, such as the electrolytic, electrothermal, electromagnetic, or electrodynamic responders.

Referring to Fig. 2, f' indicates a plate or cylinder (not essential at either transmitter or receiver) at the upper end of an elevated conductor A , which is connected to the primary coil j' of a transformer or induction-coil and thence to earth E . In a shunt around said primary j' I usually place a condenser h , preferably similar in construction and operation to the condenser e . An inductance-coil g' of variable inductance is interposed in the primary circuit of the transformer, being preferably located between the cylinder f' and the coil j' , and the inductance of said coil may be adjusted in accordance with the method described by me in my Letters Patent of the United States No. 676,332 to harmonize with the inductance of coil g at the transmitting-station, Fig. 1 of the accompanying drawings, or with that of the coil or coils at one or more of the transmitting-stations included in the communicating system.

The secondary coil j'' of the transformer is wound in two parts, preferably as described in my United States Letters Patent No. 668,315, dated February 19, 1901, and the outer ends of said coil are connected in certain cases through one or more interposed inductance-coils g'' , preferably of variable inductance, with the terminals of a coherer T or other detector of electrical oscillations. The inner ends of the split secondary coil are connected to the plates of a condenser j''' . A condenser h' is sometimes included in a shunt around the detector T . B is a battery, and R a relay connected to the condenser j''' and controlling a telegraphing instrument or a printing device. c' and c'' are choking-coils preventing oscillations from the secondary j'' running into the battery-circuit, and thereby confining them to the wave-responsive device.

The capacity and self-induction of the four circuits—*i. e.*, the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other.

In employing this invention to localize the

transmission of intelligence at one of several receiving-stations the time period of the circuits at each of the receiving-stations is so arranged as to be different from those of the other stations. If the time periods of the circuits of the transmitting-station are varied until they are in resonance with those of one of the receiving-stations, that one alone of all of the receiving-stations will respond, provided that the distance between the transmitting and receiving stations is not too small.

The adjustment of the self-induction and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred. In practice I have found the following preferred details of arrangements of apparatus to work well: The aerial conductors A at all stations and the conductor for the transformer-windings at the receiving-stations are composed of seven strands of copper wire 889 millimeters in diameter. The transformer at the transmitting-station may be of any of the following forms:

1. Around a block or core d' , preferably a square block—say .17 meters wide—of insulating material is wound a primary coil d in length .946 meters, while the secondary d'' consists of two turns or squares, one lying on each side of the primary. (See Figs. 3 and 4.) The insulation of both primary and secondary consists of 1.25 millimeters of rubber and one millimeter of jute, making a total thickness of 2.25 millimeters.

2. A transformer in all essential respects similar to 1, but with a primary of 1.93 meters and the core or block on which both primary and secondary are wound, is .3048 meters wide.

3. A transformer having a cylindrical core 10.16 centimeters in diameter and with a primary having ten turns wound thereon; over this, but separated by two millimeters of paper or other insulant, the secondary, also of ten turns.

Various forms of transformers, &c., which may be employed by me are described in my British Patent No. 7,777 of 1900.

The inductance-coils g and g' are preferably of copper wire 6.25 millimeters in diameter, wound on a cylinder 10.64 centimeters in diameter, with an interval of 2.28 millimeters between adjacent turns. The inductance-coils g'' at the receiving-station are preferably of silk-covered copper wire .19 millimeter diameter wound upon cylinders 3.7 centimeters in diameter.

Various forms of induction-coils j' j'' may be used. Figs. 5, 6, 7, and 8 show details of different forms. The figures show diagrammatically greatly-enlarged longitudinal sections not strictly to scale. Instead of showing the section of each coil or layer of wire as a longitudinal row of dots or small circles,

as it would actually appear, it is for simplicity shown as a continuous longitudinal straight line.

Referring to Fig. 5, the primary j' preferably consists of 3.046 meters of silk-covered copper wire, say, and seventy-one millimeters in diameter wound in one layer on a core of ebonite or other insulating material 2.9 centimeters in diameter. Insulating material is wound over and on each side of this, so as to make a cylindrical core, say, 3.13 centimeters in diameter, on which is wound the secondary, each half of which consists of 6.4 meters of silk-covered copper wire .19 millimeter in diameter joined to 13.41 meters of silk-covered copper wire .37 millimeter in diameters wound in the same sense as the primary, the thinner wire being over the primary and the thicker being beyond the ends thereof.

The form of induction-coil shown in Fig. 6 has a primary of one hundred turns of copper wire .037 centimeters in diameter wound on a core j' (2.9 centimeters in diameter) with a single silk covering and coated with paraffin-wax. The secondary j'' is of copper wire .019 in diameter, insulated with a single silk covering, and is wound over the primary, commencing in the middle and in the same way as the primary. Each half of the secondary is in layers of the following number of turns: first layer, seventy-seven turns; second layer, forty-nine turns; third layer, forty-six turns; fourth layer, forty-three turns; fifth layer, forty turns; sixth layer, thirty-seven turns; seventh layer, thirty-four turns; eighth layer, thirty-one turns; ninth layer, twenty-eight turns; tenth layer, twenty-five turns; eleventh layer, twenty-two turns; twelfth layer, nineteen turns; thirteenth layer, sixteen turns; fourteenth layer, thirteen turns; fifteenth layer, ten turns; sixteenth layer, seven turns; and seventeenth layer, three turns, making five-hundred turns in all.

A third form of induction-coil (shown in Fig. 7) has a primary of 3.048 meters of silk-covered copper wire .19 millimeter in diameter and a secondary of 30.48 meters of silk-covered copper wire .1 millimeter in diameter wound in one layer on a core four centimeters in diameter, the primary being in one layer outside of the secondary.

The fourth form of induction-coil is shown in Fig. 8. Its primary consists of 3.048 meters of silk-covered copper wire .37 millimeter in diameter wound on a core 2.9 centimeters in diameter and inserted in a tube j^x of four centimeters external diameter, on which is wound the secondary of 27.432 meters of silk-covered copper wire .12 millimeter in diameter, the break at the middle of the secondary being over the middle of the primary.

Other forms of transformers which may be employed by me are described and claimed in my British Patent No. 7,777 of 1900.

The following tables give preferred adjustments, those details opposite any tune in the transmitting-station table being of course used in connection with those opposite the same tune in the receiving-station table:

5

Transmitting-Station.

Tune.	Aerial conductor.	Transformer <i>d d'</i> .	Inductance number of turns of <i>g</i> includ. <i>d</i> .	Capacity microfarads <i>e</i> .	Length of spark in millimeters.
No. 1.	36.576 meters of cable.	No. 1.	None.	.000934	3
No. 2.	do.	No. 1.	45	.016395	4
No. 3.	do.	No. 2.	None.	.004112	3
No. 4.	do.	No. 2.	100	.016849	4
No. 5.	Zinc cylinder 9.144 meters long, 1.524 meters in diameter, and hoisted 3.048 meters above ground.	No. 2.	None.	.001600	12.5
No. 6.	30.48 meters of cable.	No. 3.	None.	.000573	4

Receiving-Station.

Tune.	Induction-coil.	Capacity in microfarads of—		Inductance introduced in—	
		<i>h</i> .	<i>h'</i> .	Number of turns. <i>g'</i> .	<i>g''</i> .
No. 1.	No. 1.	Omitted.	Omitted.	None.	None.
No. 2.	No. 1.	Omitted.	.00004	45	None.
No. 3.	No. 2.	.0046	Omitted.	Up to 21 may be inserted.	None.
No. 4.	No. 2.	.0046	Omitted.	100	2 coils of 15.24 meters at each end of secondary.
No. 5.	No. 3.	Omitted.	Omitted.	None.	None.
No. 6.	No. 4.	Omitted.	Omitted.	None.	None.

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2 and that when the capacity of the condenser *e* is varied the two stations can be brought into tune by including forty-five turns of each of the coils *g g'* and by introducing a condenser *h'* of small capacity in parallel with the coherer T. Similarly the transmitter and receiver are the same for tunes 3 and 4, and when the capacity of *e* is varied the stations are tuned by including one hundred turns of each of the coils *g* and *g'* and by also including the coils *g''*.

While I have herein shown and described details of construction and of arrangement found by me to be useful, yet I do not wish to be understood as confining my claims thereto. Obviously modifications which are within my invention will readily suggest themselves to skilled persons.

What I claim is—

1. At a station employed in a wireless-tele-

graph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

2. At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described.

3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the

primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation-producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

4. In a system of syntonic wireless telegraphy, a circuit so arranged as to form a persistent oscillator, a circuit so formed as to constitute a good radiator in inductive relation thereto, means for inducing in the oscillator-circuit electric undulations of a predetermined period, and means for attuning the natural period of vibration of each of said circuits to the period of the undulations so induced.

5. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising a conductor elevated at one end and connected to capacity at the other end, said conductor including a variable inductance and an element having appreciable capacity.

6. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

7. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising an open circuit so arranged as to constitute a radiator of such waves or oscillations, and means for varying at will the natural period of vibration of the said circuit.

8. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described.

9. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected in series with an adjustable condenser and with a means which automatically causes oscillations of the desired frequency, substantially as described.

10. A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described.

11. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

12. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of the said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end, to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

13. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

14. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

15. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a condenser located in said circuit between the coil and the capacity, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

16. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

17. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

18. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving con-

ductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsive device, substantially as described.

19. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation-transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave-responsive device and a variable inductance, substantially as and for the purpose described.

20. In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described.

GUGLIELMO MARCONI.

Witnesses:

R. B. RANSFORD,
G. F. WARREN.

512-240
DISTRICT COURT OF THE UNITED
STATES. SOUTHERN DISTRICT OF
NEW YORK.

Nikola Tesla Company,

against

Marconi Wireless Telegraph
Company of America.

1500540

BILL OF COMPLAINT.

GEORGE H.D.FOSTER,

Solicitor for Complainant,
Office & P.O. Address,
32 Liberty Street,
Boro. of Manhattan,
New York City.

